

Chapter 6. Working with radiation.

6-1. Caution Signs and Labels.

a. Appropriate warnings are required in all areas, rooms, and on all containers in which significant amounts of radiation or radioactive material may be found. Warnings consist of postings and labelings. In general, areas or rooms are "posted" with signs whereas containers, devices, equipment, etc. are "labeled." The specific warning to be used depends on the type and degree of hazard present. The RPO will post rooms, hoods, work areas, etc. The AU is responsible for appropriate labeling.

(1) Posting Caution Signs.

(a) USACE policy is that any room or area in which radioactive material, covered by an NRC license, an Agreement State license, or an ARA is used or stored shall be posted "Caution, Radioactive Material".

(b) A room or area in which radioactive material is used or stored may require additional posting if the dose rate in the room or area is likely to exceed 5 mrem in any one hour at 30 cm from the source or source container. Table 6-1 specifies when a room or area must be posted as a Radiation Area, a High Radiation Area, or a Very High Radiation Area.

Table 6-1
Caution Sign Posting Requirements

Dose Rate	Distance From Source	Posting Required
1. 5 mrem in any one hour.	1. 30 cm	1. "Caution, Radiation Area"
2. 100 mrem in any one hour.	2. 30 cm	2. "Caution, High Radiation Area"
3. 500 rad in any one hour.	3. 1 m	3. "Grave Danger, Very High Radiation Area"

(2) NRC Required Labeling.

(a) When a container has a quantity of radioactive material equal to or greater than that listed in 10 CFR 20 Appendix C, a "Caution, Radioactive Material" label will be affixed to the outside of the container. Most gauges and instruments containing radioactive material, such as soil density gauges, electron capture sections of gas chromatographs, or sediment density probes will require this label. The label should be large enough to be conspicuous. Standard labels are roughly 4" x 3.5".

(b) Each AU shall, prior to disposal of any uncontaminated empty container to an unrestricted area, remove or deface the label or otherwise clearly indicate that the container no longer contains radioactive material.

(c) Be advised that this labeling requirement is separate from the labeling requirements of DOT. A package of radioactive material prepared for transportation may also need DOT labels as described in Chapter 8 - Transportation of Radioactive Material.

(d) An AU is not required to label containers when they

are attended by an individual who takes the precautions necessary to prevent the exposure of any individual to radiation or radioactive material in excess of the limits when they are in transport and packaged and labeled in accordance with DOT regulations, or containers which are accessible only to individuals authorized to handle or use them or to work in the vicinity thereof, provided that the contents are identified to such individuals by a readily available written record.

b. Signs and labels shall have a yellow background with a magenta or black standard radiation symbol. Lettering shall be magenta or black, but magenta is the preferred color.

c. Regulations require that the following information be posted in a prominent location, in sufficient numbers to be accessible to all who work in, or frequent, areas where radioactive material is used:

(1) A copy of the license or permit, conditions, references and amendments. This is usually accomplished by posting a notice of where the license, license conditions, referenced documents and amendments are kept. For

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example, "NRC License documents are kept in the District Safety Office and may be viewed by anyone upon request."

(2) Applicable operating procedures for the prescribed use of radioactive material.

(3) All notices of violations involving working conditions, civil penalties, or order, and the response from the licensee. These notices must be posted within two working days of their receipt and must be posted for a minimum of five working days or until the violation has been corrected whichever is later.

(4) NRC Form 3, "Notice to Employees" most recent version (rev. Jan 96 as of this printing), or Agreement State equivalent. (NRC Form-3 included at Appendix H.)

6-2. Airborne Radioactivity.

a. If the activities you are engaged in are suspected to create airborne radioactivity (for example, vapors or aerosols), the RPO or HP can conduct the appropriate surveys and calculations to determine if posting the area is required. If necessary, these areas will be posted with a "Caution, Airborne Radioactivity Area".

b. The RPO will arrange a time to conduct the posting of

each authorized use location prior to approving that location for radioactive material use. A facility posting checklist is utilized to document postings.

6-3. Rooms/Areas in Which Radioactive Material is No Longer Used or Stored.

The AU is responsible for notifying the RPO by memo when radioactive material usage in a room or area has ceased. The RPO will perform a close-out survey of the area to ensure no residual contamination, remove all signs and postings, document the survey and, if necessary, apply to amend or terminate all applicable NRC Licenses and/or ARAs.

6-4. Receiving Radioactive Material.

a. NRC regulations require that written instructions for receiving and opening packages be maintained and followed by all personnel receiving radioactive material. Refer to 10 CFR 20.1906 for complete guidance. The following written instructions meet the NRC requirements.

b. When a package is received it will be inspected as follows:

(1) A visual check is made to see if the package is damaged (wet or crushed). If

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there is evidence of degradation of package integrity, the package will be wipe tested for radioactive contamination and radiation levels.

(2) Wipe test the external surfaces of a labeled package (a package labeled with a Radioactive White I, Yellow II, or Yellow III label as specified in DOT regulations, 49 CFR 172) for radioactive contamination unless the package contains only radioactive material in the form of gas or in special form as defined in 10 CFR 20 or any package that appears damaged, or if the wipe test results from the shipper are not documented.

(3) Survey the external surfaces of a labeled package for radiation levels unless the package contains quantities of radioactive material that are less than or equal to the A_2 quantity listed in 10 CFR 71 Appendix A, and the radioactive material is in the form of a gas or in special form. Tables 6-2 and 6-3 list some of the common A1 (special (sealed source) form) and A2 (normal, unsealed form) values. All the A1 and A2 values can be found in 49 CFR 173.35. Surveying and wipe testing shall be performed as soon as practicable after receipt of the package, but not later than three hours after the package is received if it

is received during normal working hours, or not later than 3 hours from the beginning of the next working day if it is received after normal working hours.

(4) The receiver will immediately notify the final delivery carrier and, by telephone and telegram, mailgram, or facsimile, the RPSO, and the NRC when removable radioactive surface contamination exceeds 2200 disintegrations per minute (dpm)/100 cm^2 beta, gamma or 220 dpm/100 cm^2 alpha or if the external radiation level exceeds 200 mrem per hour at any point on the external surface of the package or 10 mrem per hour at 1 meter from the package.

(5) When a radioactive material package is received, there is a chance the radioactive material has leaked out of the inner container. One could receive a radiation exposure if a contaminated package is opened without taking proper precautions. Always assume a radioactive material package is contaminated until proven otherwise.

c. SOPs for opening packages should be developed for each site receiving and opening radioactive material packages. The following guidance may assist in

preparing the procedure:

- (1) wear gloves.
- (2) check to be sure the contents match the packing slip.
- (3) remove and wipe test the inner container if contamination is suspected. Do not release the contents until the wipe test results have been obtained.
- (4) if contamination is not found, store the radioactive material in a secure storage area that is conspicuously posted for

radioactive material, as required above.

(5) if contamination is found, dispose of all contaminated shipping material as radioactive waste. If the radioactive material is still usable, clean the outside of the container, and store in an area posted as necessary, for radioactive material. Survey the receipt area for contamination.

(6) deface or remove all labels on the uncontaminated shipping box and dispose of as normal trash.

Table 6-2 Typical A ₁ Quantities in Special (sealed source) Form:			
H-3	1000 Ci	Ba-133	40 Ci
C-14	1000 Ci	Cs-137	30 Ci
Na-22	8 Ci	Pm-147	1000 Ci
P-32	30 Ci	Tl-204	300 Ci
S-35	1000 Ci	Po-210	200 Ci
Co-57	90 Ci	Ra-226	10 Ci
Fe-59	10 Ci	Th-232	unlimited
Co-60	7 Ci	U-238	unlimited
Ni-63	1000 Ci	Am-241	8 Ci
Sr-90	10 Ci	Cf-252	2 Ci
I-125	1000 Ci		

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Table 6-3

Typical A₂ Quantities in Normal(unsealed) Form:

H-3	20 Ci	Cf-252	0.009 Ci
C-14	60 Ci	Ba-133	10 Ci
Na-22	8 Ci	Cs-137	10 Ci
P-32	30 Ci	Pm-147	25 Ci
S-35	60 Ci	Tl-204	10 Ci
Co-57	90 Ci	Po-210	0.2 Ci
Fe-59	10 Ci	Ra-226	0.05 Ci
Co-60	7 Ci	Th-232	unlimited
Ni-63	100 Ci	U-238	unlimited
Sr-90	0.4 Ci	Am-241	0.008 Ci
I-125	70 Ci		

6-5. Radioactive Material and Radiation Generating Device Inventory.

a. The RPO for each USACE Command is responsible for all radioactive material and radiation generating devices owned or possessed by the Command, regardless of whether the material and radiation generating device is authorized under a general license, a specific license, or ARA. In order to ensure control of all radioactive material and radiation generating devices, the RPO shall maintain a written inventory of all radioactive material and radiation generating devices within the Command. Inventory should be categorized into NRC specifically licensed materials, NRC generally licensed materials, ARA authorized materials, and radiation generating devices.

The inventory shall be kept on ENG Form 3309-R "Record of Radioactive Material". A copy of this form is attached at Appendix H.

b. The RPO for each Command owning or possessing radioactive material or radiation generating devices shall physically inventory each item at least semi-annually, and more often if their license requires it. This will usually be accomplished along with the semi-annual wipe test. For remote sources, such as those assigned to dredges, the RPO may have an AU perform the physical inventory of the item(s).

6-6. Storing Radioactive Material.

The AU is responsible for assuring that all radioactive material is stored in a secure

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manner when not in use. Sealed sources used in the field may be locked in their storage containers. Sealed sources stored in a building may be locked in a storage room or storage cabinet. Unsealed sources may be locked in a storage container, cabinet, drawer, refrigerator, or freezer. Labs where unsealed sources are used shall be locked whenever the lab is unattended. Sealed sources in fixed use locations may be secured in their work position. The AU must ensure that where ever radioactive sources are stored, proper labeling and posting, as per paragraph 6-1 is used.

6-7. Contamination Control.

a. Depending upon the types and quantities of radioactive material in use, contamination surveys may be made directly with portable survey instruments or indirectly (removable contamination survey, wipe or swipe survey) by wiping surfaces (approximately 100 cm²) with a filter paper and counting the wipes.

A direct contamination survey is performed using a meter and detector appropriate to the nuclides in use in the area. For example, if surveying for P-32 contamination, one would use a GM detector (probe); for I-125, one would use a thin

window NaI scintillation detector (probe). An ionization chamber would not be appropriate for a contamination survey. At the beginning of each day of use, an instrument's operability should be checked with a suitable check source. Each meter has an integrator circuit and it will take time for it to properly respond. It is highly suggested that meters be equipped with audio circuits so a surveyor can hear a change in 'click' rates and resurvey suspected 'hot spots'.

b. Removable contamination consisting of low energy beta or alpha emitting radionuclides, such as H-3, C-14, or Pu-239, is best detected through the use of wipes and liquid scintillation counting since the beta emissions from these radionuclides have insufficient energy to be efficiently detected by portable survey instruments, and the alpha emissions have of too short of a range in air to be easily detected. Wipes may also be appropriate when attempting to detect contamination in areas with higher than background radiation levels. For example, the use of a GM survey meter to detect contamination would not be practical if radiation levels in an area are already elevated from radioactive material stored within the area. In this situation, a

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wipe test could be performed and the wipe counted at a location away from the radiation field.

c. When radiation levels in an area are normal background, portable survey instruments can be quite effective in detecting certain types of radioactive contamination. Most GM meters can detect P-32 with efficiencies exceeding 20%. I-125 can be detected at efficiencies nearing 20% with a thin crystal (NaI) scintillation probe. All survey instruments are only as good as their maintenance. A portable survey meter, in most cases must be calibrated at least once every year and operability verified each day of use with a check source.

6-8. Wipe Tests.

a. A wipe test, also called a 'smear' or 'swipe' test, is collected using various materials. The most common material is a filter paper type material designed specifically for this purpose. This material can be used wet or dry but dry wipe tests are preferred. Dry tests are preferred if the chemical form of the radionuclide is not known. If it is not water soluble, a wipe with a wet swab will not collect as much of the contaminant as a dry swab. Conversely, if a swab is wetted

with an oil based solvent, water soluble contaminants will not be collected as efficiently. Additionally, many solvents are hazardous materials, and should radioactive contamination be found, the swab may become a mixed or commingled waste. The wipe test is performed by physically wiping the area to be checked.

b. If water is used to moisten the material, caution must be used to not saturate the material and to allow the material to dry prior to measurement. Water will attenuate alpha emitters and allow for false readings when read with a survey meter or some counting systems. The NSN for a box of 500 wipe testers is 6665-01-198-7573 (a 2-inch diameter Whatman filter paper works well also). Another common method for small spaces is the use of cotton swabs, similar to 'Q-tips.' A NSN for a package of these is 6515-00-890-1475.

c. Wipe testing is performed by using the wipe or filter paper or cotton swab and wiping it over an area approximately 100 square centimeters. Wipe tests are performed using normal finger pressure on a dry filter paper or swab and wiping in an "S" shape for a distance of 50 centimeters and wiping again in a backwards "S" shape at right

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angles to the first one for another 50 centimeters. The wipe is then analyzed on site or packaged in an envelope and sent to a lab for analysis. If an item is too small or irregularly shaped for this procedure, then wipe the entire surface area of small items or an accessible 100 square centimeter area of irregular shaped items.

d. Suggested limits for removable contamination are listed in Table 6-4. Whenever radioactive contamination is found, reasonable efforts should be made to remove all contamination.

6-9. Leak Testing.

a. Many sealed sources are required by license or authorization conditions to be leak tested periodically. Leak tests are typically required every six months. But some license conditions may require more frequent testing. A leak test is performed in a manner similar to a wipe test. The primary difference is that most sealed sources emit much more radiation than most contamination, and for ALARA purposes it is best to keep as much distance between the source and the person performing the leak test. This is done by using long handled cotton swabs or forceps to hold the filter paper swab, increasing the distance between

the source and the hand. The wipe, or swab should then be placed in its own plastic bag or glycine envelope to avoid potentially contaminating other wipes or areas. Since many Commands do not have the instrumentation available to determine the amount of contamination from a leak test, most leak test wipes are sent to a lab for analysis. USACE leak tests shall be sent to USAIRDC for analysis.

b. The limits for contamination of sealed sources is 0.005 μCi per wipe.

Table 6-4
Acceptable Surface Contamination Levels

NUCLIDE ^a	AVERAGE ^{b c} dpm/100 cm ²	MAXIMUM ^{b d} dpm/100 cm ²	REMOVABLE ^{b e} dpm/100 cm ²
U-nat, U-235, U-238 and associated decay products	5,000 p	15,000 p	1,000 p
Transuranics, Ra-226, Ra-228, Th-230, Th-228, Pa-231, Ac-227, I-125, I-129	100	300	20
Th-nat, Th-232, Sr-90, Ra-223, Ra-224, U-232, I-126, I-131, I-133	1,000	3,000	200
Beta-gamma emitters (nuclides with decay modes other than alpha emission or spontaneous fission) except Sr-90 and others noted above.	5000 β-p	15,000 β-p	1,000 β-p

^a Where surface contamination by both alpha- and beta-gamma-emitting nuclides exists, the limits established for alpha- and beta-gamma-emitting nuclides should apply independently.

^b As used in this table, dpm (disintegrations per minute) means the rate of emission by radioactive material as determined by correcting the counts per minute observed by an appropriate detector for background, efficiency, and geometric factors associated with the instrumentation.

^c Measurements of average contaminant should not be averaged over more than 1 square meter. For objects of less surface area, the average should be derived for each object.

^d The maximum contamination level applies to an area of not more than 100 cm².

^e The amount of removable radioactive material per 100 cm² of surface area should be determined by wiping that area with dry filter or soft absorbent paper, applying moderate pressure, and assessing the amount of radioactive material on the wipe with an appropriate instrument of known efficiency. When removable contamination on objects of less surface area is determined, the pertinent levels should be reduced proportionally and the entire surface should be wiped.

6-10. Exposure Rate Surveys.

In addition to contamination monitoring, it is also important to assess exposure rates resulting from the

storage and use of relatively large quantities of high energy beta or gamma emitters. This information is important in planning and evaluating the control of time, distance, and

shielding in order to minimize personnel exposure. In some situations, a GM meter calibrated at or near the energy of the radiation measured, can give a reasonable estimate of the exposure rate. An ionization chamber will give the most accurate estimate of exposure and should be used whenever measuring exposures to determine posting requirements, measuring the transport index (TI) of a package, or when exposures are more than a few millirems.

6-11. Accident/Incident Response.

a. There is always a possibility of an accident involving radiation or radioactive material. USACE will strive for a zero accident tolerance level. This can be accomplished using Standing Operating Procedures, conscientious work practices, and having and practicing an Accident / Emergency Response Plan. The plan, required for all HTRW sites, must provide guidance for response to fire, natural disasters, radioactive material spill, and inadvertent radiation exposure. The plan will address the following procedures:

(1) Evacuation of the building/area;

(2) Treatment of injured personnel;

NOTE Never delay treatment of an injured person because of actual or potential radioactive contamination.

(3) Firefighting;

(4) Spill response;

(5) Personnel decontamination; and

(6) Any additional site specific requirements.

6-12. Accident/Incident Reporting.

a. Any individual suspecting or knowing of an accident, incident, loss or theft involving radioactive material or radiation will notify the RPO as soon as possible. The RPO will notify the RPSO immediately of any accident, incident, loss or theft that requires reporting to the NRC or other regulatory agency. The RPO will notify the NRC, OSHA or other regulatory agency in the required time frame, of all accidents, incidents, losses or thefts that require reporting. The RPSO will notify HQDA (DACS-SF) of all NRC, OSHA or other agency notifications within the same time frame as required by the agency. The RPSO will also notify DASG-PSP of all exposures exceeding Tier 1 dose limits or OSHA dose limits and submit copies of reports to other agencies to

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DASG-PSP as required by the Army Radiation Protection Program. All telephone reports will be followed up by a written report within 30 days.

b. All written reports will address the following items:

(1) A description of the material involved, including the kind, quantity and chemical and physical form of the material,

(2) A description of the circumstances surrounding the incident,

(3) A statement of the disposition, or probable disposition of the material involved,

(4) An estimate of doses received by any individuals, and the circumstances of the exposure,

(5) Actions taken, and

(6) Procedures or measures proposed or adopted to prevent recurrence.

c. The following are some of the reportable accidents/incidents, and the required reporting times:

(1) Theft or loss of 1000 times the 10 CFR 20, Appendix C quantity of a radioactive material must be reported

immediately;

(2) Theft or loss of 10 times the 10 CFR 20, Appendix C quantity of a radioactive material must be reported within 30 days;

(3) Incidents that cause or threaten to cause an individual to receive 25 rem TEDE, 75 rem EDE, or 250 rem Shallow Dose Equivalent (SDE), must be reported immediately;

(4) A release of radioactive material, either inside or outside a restricted area, that could possibly result in a 24-hour dose of greater than five times the annual limits must be reported immediately;

(5) Incidents that cause or threaten to cause an individual to receive 5 rem TEDE, 5 rem EDE, or 50 rem SDE, must be reported within 24 hours;

(6) Release of radioactive material, either inside or outside a restricted area, that could possibly result in a 24 hour dose of greater than the annual limits must be reported within 24 hours.

(7) Incidents that cause an occupational worker, member of the public, a minor or an embryo/fetus of a declared pregnant woman to receive a dose in excess of the

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appropriate regulatory dose, must be reported within 30 days;

(8) A release of radioactive material, inside a restricted area, greater than the license limits must be reported within 30 days;

(9) A release of radioactive material, outside a restricted area, greater than 10 times any license limit, regardless of any exposure to an individual, must be reported within 30 days.

d. Reports must include the information required in 10 CFR 20 Subpart M, or as required by other regulatory agencies.

6-13. Audits and Reviews.

a. The RPSO, or their designee, will audit each Command that possesses a radioactive material license or ARA tri-annually. The audit is to ensure personnel safety and compliance with regulatory requirements. The audit may consist of a records review, facility inspection, interviews with the RPO and AUs, and an exit interview with the RPC or the Commander, depending on the activity at the Command. The audit will be documented and a copy furnished to the Commander and the RPO.

b. The RPO will review

their Radiation Protection Program annually for content and implementation. The RPO will assure that the quality and timeliness of their program meet the radiation safety guidelines outlined in this manual. The RPO will review all work with radiation within his/her Command. The RPO will perform the annual review with the purpose of anticipating the needs of the program in the coming year. The review will be documented and a copy forwarded to the RPSO.

c. Additional audits and reviews may be performed as deemed beneficial to the Command by the RPSO, the RPO, or the Commander.

d. Documentation Audits. Documentation audits may be performed by the RPSO or their designee for Commands with an NRC license or ARA where little health risk is posed by radiation. A document audit will consist of a review of the radioactive materials license or ARA, the inventory, personnel dose histories, receipt, transfer, and disposal records, and leak test results. Deficiencies may include incomplete or inaccurate documentation. Significant or multiple deficiencies may initiate a field audit.

e. Field Audits. Field audits will be performed by the RPSO or their designee for

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Commands where the use of radioactive materials or radiation generating devices has the potential to present greater health risks to USACE personnel or the public. A field audit will consist of a documentation audit and an on-site inspection. The inspection will concentrate on proactive radiation protection procedures and processes. These may include:

(1) ensuring proper posting and labeling,

(2) ensuring proper use of dosimetry,

(3) ensuring proper and secure storage of radioactive materials,

(4) ensuring that radiation monitoring equipment

is of the proper type for the radiation used; that the instruments have been calibrated in a timely manner; and that personnel know the correct methods of surveying for radiation and contamination,

(5) ensuring that any transportation of radioactive materials complies with NRC and DOT regulations.

f. U.S. Army Center for Health Promotion and Preventive Medicine (USACHPPM) Surveys. Presently, USACHPPM surveys USACE Commands annually. USACHPPM surveys follow a sample protocol/checklist presented at Appendix I.